AN INVESTIGATION OF THE ENGINEERING AND ECONOMIC PHASES OF THE REDUCTION OF A SPECIFIC RULING GRADE ON THE ILLINOIS CENTRAL RAILROAD--- BY THE METHOD OF "REDUCTION BY DIVERSION"

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

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ENTITLED AN INVESTIGATION OF THE ENGINEERING AND ECONOMIC PHASES OF THE REDUCTION OF A SPECIFIC RULING GRADE ON THE ILLINOIS CENTRAL RAILROAD.- BY THE METHOD OF "REDUCTION BY DIVERSION"

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Railway Civil Engineering

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This thesis consists of a consideration of the physical conditions pertaining to the prosecution of the particular work; the calculations necessary to determine the saving which will be effected by the proposed reduction; an estimate of the cost of doing the work; and an appendix consisting of:

(1) Estimate of the total cost of a mile of main track

(2) Estimate of the total cost of a mile of side track

(3) Estimate of the value of one mile of old track

(4) Estimate of the cost of one road crossing exclusive of the grading

(5) Estimate of the cost of one number 10 turnout complete

(6) Working profile of the district where it is proposed to reduce the grade, the new grade line being shown in red.

(7) A chart showing the tonnage hauled daily, both north bound and south bound, from March 31st to May 31st 1905 inclusive.

(8) A chart showing the number of trains monthly both north bound and south bound for the same period of time.

The distance between the terminal points of the division under consideration is forty miles. Owing to the disinclination of the railway officials to make public any information regarding specific portions of their property, these terminal points will, in this thesis, be termed A and B. A is the northern end of the division.

The accompanying profile shows a part of this division on which the actual maximum grade against south bound traffic is 1.03%, a portion of this grade being on a 4°00' curve. It is common practice to consider that for each degree of this curve 0.04% is added to the grade. Therefore, the effective maximum grade against south bound traffic is 1.19% or 62.8 feet per mile. The profile also shows the maximum grade against north bound traffic to be 0.81% or 42.8 feet per mile. On the part of the division, not shown by the profile, the maximum grade is 0.3% or 16.4 feet per mile compensated for curvature.

Other roads with which this division must compete, have maximum grades of 0.3% compensated. In order to meet their competition upon an equal basis, it is proposed to so reduce grades that the maximum on the whole division will be 0.3%, compensated. From a consideration of the traffic statistics herein contained, it might seem that it would not be economical to reduce the grade against north bound traffic to the same extent as that against south bound traffic. Inspection of the tonnage chart will show however, that while the preponderance of the tonnage is south bound, there are often periods when the north bound tonnage exceeds the south bound tonnage. Taking into account of this fact, it was deemed best to reduce the grade to 0.3% in both directions.

The construction work is to be done by the method of "Reduction by Diversion." That is, the old track is to be thrown as far as possible to one side of the present cuts and fills. The new cuts and fills will then be so made as to not interfere with the movement of traffic over the old line. New track is to be laid on the revised grade and when it is sufficiently stable

to carry the traffic, the old track will be taken out.

From March 1, 1905 to May 31, 1905 inclusive, the trains run and the tonnage hauled on this division, were as follows:

	Loads	Empties	Trains	Tons	Average Tons per Train
Class A					
North Bound	4457	345	140	185180	1323
South Bound	5714	439	146	207892	1424
Class B					
North Bound	6520	7831	324	417420	1288
South Bound	12743	987	384	463771	1208
Total Class A and Class B					
North Bound	10977	8176	464	602600	1299
South Bound	18457	1426	530	671663	1267

The above statistics do not take into account light engines or "turn-around" crews run over the division. The number of loads and empties was taken from an actual check of the train sheets. The tonnage shown is the gross tonnage. The amount of this tonnage was arrived at arbitrarily. It was found by an actual experiment, carried on under the direction of the division Superintendent that the gross weight in tons of the north bound traffic might be very closely approximated by multiplying the number of empty cars by 20 and the number of loaded cars by 40 and adding the results. Similarly, the gross weight, in tons, of the south bound traffic is equal to the number of south bound loads multiplied by 35 plus the number of south bound

empties multiplied by 18.

In the calculations which follow, the total tonnage, Class A and Class B, south bound, will be used as a basis from which to figure. This, for the reason that the greater tonnage determines the number of trains which have to be run. It will be remembered that the maximum grade against south bound traffic is 1.19%.

The 801 class Locomotives in use on this division have 63" drivers, 22"x 30" cylinders, and work normally under a boiler pressure of 200 pounds per square inch. The weight on their drivers is 90.5 tons and the total weight of the engine and tender is 174 tons.

Two formulae are in general use for the calculation of locomotive rating. They are;

$$R = \frac{AW'}{R_{GT}} - W$$

Where,

R = rating behind the tender in tons.

A = coefficient of adhesion between the drivers and the rail. This averages 0.225. (Wellington p. 437).

W' = weight on the drivers in pounds.

W = total weight of the engine and tender in tons.

R_{GT} = train resistance plus the grade resistance in pounds per ton.

and,

$$R = \frac{0.85pd^2s}{DR_{GT}} - W$$

Where,

R, W and R_{GT} are as above.

p = boiler pressure in pounds per square inch.

d = diameter of cylinder in inches.

s = length of stroke in inches.

D = diameter of the drivers in inches.

The mean effective pressure in the cylinder has an average value of about 85% of the boiler pressure.

Using 6.1 pounds per ton for the train resistance, as approved by the motive power department, and substituting in the first of the above formulae, we have for the rating of the 801 class engines,

on a 0.3% grade ---------- 3192 tons

on a 1.19% grade ---------- 1188 tons

Similarly, from the second formula we find the rating to be,

on a 0.3% grade ---------- 3064 tons

on a 1.19% grade ---------- 1136 tons

The latter values will be used in the following calculations, for, if the assumptions which were made in connection with these formulae are correct, the one which gives the smaller values in any particular case is the one to use.

At the present time, a pusher engine service is maintained over the district of the proposed reduction. Considering the two engines now hauling the trains, we find that their combined theoretical ratings on the 1.19% grade is 2272 tons. The theoretical rating of one engine on the 0.3% grade is 3064 tons. The tonnage statistics show that the average train load south bound at the present time is 1267 tons. It is fair to assume that the average train load will increase directly as the rating increases. Therefore, the average train load after the reduction will be,

$$\frac{1267 \times 3064}{2272} = 1709 \text{ tons.}$$

The number of trains required to handle the business on the new grade will be $\frac{671663}{1709} = 393$

The number of trains saved in the three months for which statistics are given is, 530 – 393 = 137.

Assuming that the conditions of traffic, as shown by the statistics for the months of March, April and May 1905, will continue in the future, we have,

Number of trains saved by the reduction in one year =

137 x 4 = 548.

Number of train miles saved in one year = 548 x 80 = 43840.

Each train mile saved is considered as being worth $0.50 to the Company.

The yearly saving due to the elimination of 43840 train miles at $0.50 per train mile is $21920.00.

The profile shows that, by the reduction, 24 feet of Class A and 40 feet of Class B "Rise and Fall" (Wellington's Classificat-

ion) are eliminated. The saving is as follows:

24 feet of Class A "Rise and Fall" at $3.50 per foot per daily train# per year $ 487.89

40 feet of Class B. "Rise and Fall" at $4.50 per foot per daily train per year 1045.44

The total yearly saving due to the elimination of "Rise and Fall" will be $1533.33.

The cost of operating the pusher engine will be saved. For one year this is, 365 pusher engine days at $50.00 = $18250.00.

Adding together the savings from the three sources, we get, $41703.33 as the total annual saving due to the change from a 1.19% to a 0.3% maximum grade.

The following is a detailed estimate of the cost of bringing about this change.

#By "daily train," one train each way per day is meant. The average number of daily trains is 5.808.

Estimate of Cost of Grade Reduction---A to B. Grade reduced to 0.3% against both north and south bound traffic. Proposed reduction by the method of diversion.

Grading:

203771 Cu.yd. of Earth Excavation,			
Main Track at	----------	$0.45--	$91696.95
17163 Cu.yd. of Earth Excavation,			
Side Track at	----------	0.45--	7723.35
2200 Cu.yd. of Earth Excavation,			
Road Crossing,Sta.3164 at	--------	0.45--	990.00
275 Cu.yd. of Earth Excavation,			
Road Crossing,Sta.3234 plus70 at	-	0.45--	123.75
			100534.05

Culverts:

Box culvert Sta. 3026 plus 50			
85 Cu.yd. concrete at	----------	$8.00---	$680.00
9457 lb. steel at	----------	.05---	472.85
Sta. 3036 plus 50			
50 ft. 24" C.1 Pipe--6.15 tons at	---	$40.00---	246.00
Sta. 3088 plus 80			
68 ft. 36" C.1 Pipe-13.97 tons at	---	40.00---	558.80
Sta. 3159 plus 50			
18 ft. 24" C.1 Pipe- 2.21 tons at	---	40.00---	88.40
Sta. 3198 plus 10			
18 ft. 24" C.1 Pipe- 2.21 tons at	---	40.00---	88.40
Sta. 3226 plus 00			
30 ft. 36" C.1 Pipe- 6.17 tons at	---	40.00---	246.80
			2381.25

Main Track:

Sta. 3269 to 3274--500 ft. to be lifted an average lift of one ft. under traffic, at $0.15 per ft.---------- $75.00

Sta. 3004 to 3010--600 ft. thrown over an average of three ft. at $0.15 per lin. ft.---- 90.00

Sta. 3010 to 3269--4.9 miles of new main track laid with 85 lb. rail, complete with ballast, ties, labor, etc., at $11100.00----------54390.00

54555.00

Side Track:

Sta. 3125 plus 18 to 3160 plus 82 – 0.675 mi. of side track – 60lb. rail at $6700.00----$4522.50

2 Turnouts complete---------- at 285.00---- 570.00

5092.50

Road Crossings:

Sta. 3100 plus 80

1 Road Crossing complete $ 65.00

Sta. 3055 plus 70

1 Road Crossing complete 65.00

Sta. 3164 plus 00

1 Road Crossing including drain tile 73.00

Sta. 3234 plus 70

1 Road Crossing including drain tile 73.00

276.00

Buildings:

Sta. 3163 plus 00---Moving Depot 50 ft. at $10.00 per ft.--	$500.00
	$163338.80
Credit:	
49 miles of old track at $2800.00----------	14720.00
	149618.80
Engineering and Contingencies----------	15381.20
Total----------	$165000.00

From the preceding, we see that the cost of construction is only $165000.00. The annual saving is $41703.33. With the interest rate for money at 5%, this represents a justifiable expenditure of $834066.60. It would seem therefore, from these figures, that this betterment is one which should be authorized at the earliest possible date.

A P P E N D I X

ESTIMATE

OF

TOTAL COST PER MILE OF MAIN TRACK.

MATERIAL AND LABOR OF LAYING SAME.

85 lb. Rail.

Ties: 18 to 30 ft. Rail 3168 ties at $.60	$1900.80
Rail: 133.57 Tons at $30.00	4007.10
Angle Bars: 358 Pairs at $1.02	365.16
Bolts: 14.4 Kegs at $5.20	74.88
Spikes: 33.8 at $3.60	121.68
Nut Locks: 2148 at $5.50 per M	11.82
Ballast: 3010 Cu. Yds of Rock Ballast at $.90	2709.00
Labor of Laying Track: 5280 ft. at $.15	792.00
Work Train Service: 6 Work Train Days at $25.00	150.00
	$10132.44
Engineering and Contingencies	967.56
	$11100.00

ESTIMATE

OF

TOTAL COST PER MILE OF SIDE TRACK.

MATERIAL AND LABOR OF LAYING SAME.

60 lb. Rail.

Ties: 18 to 30 ft. Rail 3168 at $.40	$1267.20
Rail: 94.29 tons at $20.00#	1885.80
Angle Bars: 358 Pairs at $.70	250.60
Bolts: 14.4 Kegs at $5.20	74.88
Spikes: 33.8 Kegs at $3.60	121.68
Nut Locks: 2148 at $5.50 per M	11.82
Ballast: 2000 cu. yds. of Ballast at $.75	1500.00
Labor of Laying Track: 5280 ft. at $.15	792.00
Work Train Service: 6 Work Train Days at $25.00	150.00
	$6053.98
Engineering and Contingencies	646.02
Total	$6700.00

#Relayed rail.

ESTIMATE

OF

VALUE OF ONE MILE OF OLD TRACK.

Ties:	
3168 ties at $.40	$1267.20
Rails:	
13357 tons at $20.00	2671.40
Angle Bars:	
358 pairs at $.70	250.60
	4189.20
Less cost of taking up 5280 ft.	1389.20
Credit per mile	$2800.00

ESTIMATE OF THE COST
OF ONE
ROAD CROSSING
EXCLUSIVE OF GRADING.

Cattle Guards		$12.00
Wing Fences		12.96
Warning Sign		3.50
2 Whistle posts	at $1.50	3.00
Planking		
675 ft. B. M.	at $40.00 per M	27.00
Boat Spikes		
10 lb.	at 5¢	0.50
		58.96
Labor		6.04
	Total	$65.00

Note: If Crossing is in a cut add $8.00 for drain tile.

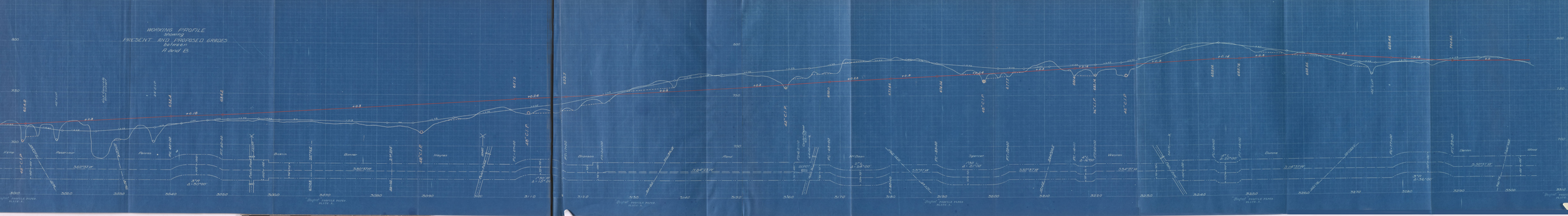
Estimate
of
Cost of a No. 10 Turnout

Complete with 85 lb. Rail.

Note:
Rail includes one rail length back of heel of frog. Distance from point of switch to end of rail as above is 118 ft.

Switch Ties:	
3510 ft. B. M. of 6" x 10" ties at $18.00 per M.	$63.18
Cross Ties:	
6 Cross Ties at 60¢	3.60
Rail:	
175 ft. of 85 lb. Rail--321 tons at $30.00	66.30
Angle Bars:	
8 Pairs at 70¢	5.60
Bolts:	
48 Bolts--.19 Keg at $5.20	1.00
Nut Locks:	
50 at $5.50 per M.	0.28
Spikes:	
470 Spikes--1.25 Kegs at $3.60	4.50
Frog:	
One No. 10,-14 ft.-85lb., Spring Frog at $35.00	35.00
Frog Guard Rails:	
2,-15 ft.-85 lb. Frog Guard Rails at $14.00 per Pr.	14.00
Bolts for same 4-10" x 3/4" and 4-8"x 3/4 Bolts 25 lb. at $2.60 per Cwt.	0.65
2 Sets of fillers for same at $1.30	2.60
Switch Points:	
2-15 ft.-85 lb. Switch Points at $17.00	34.00

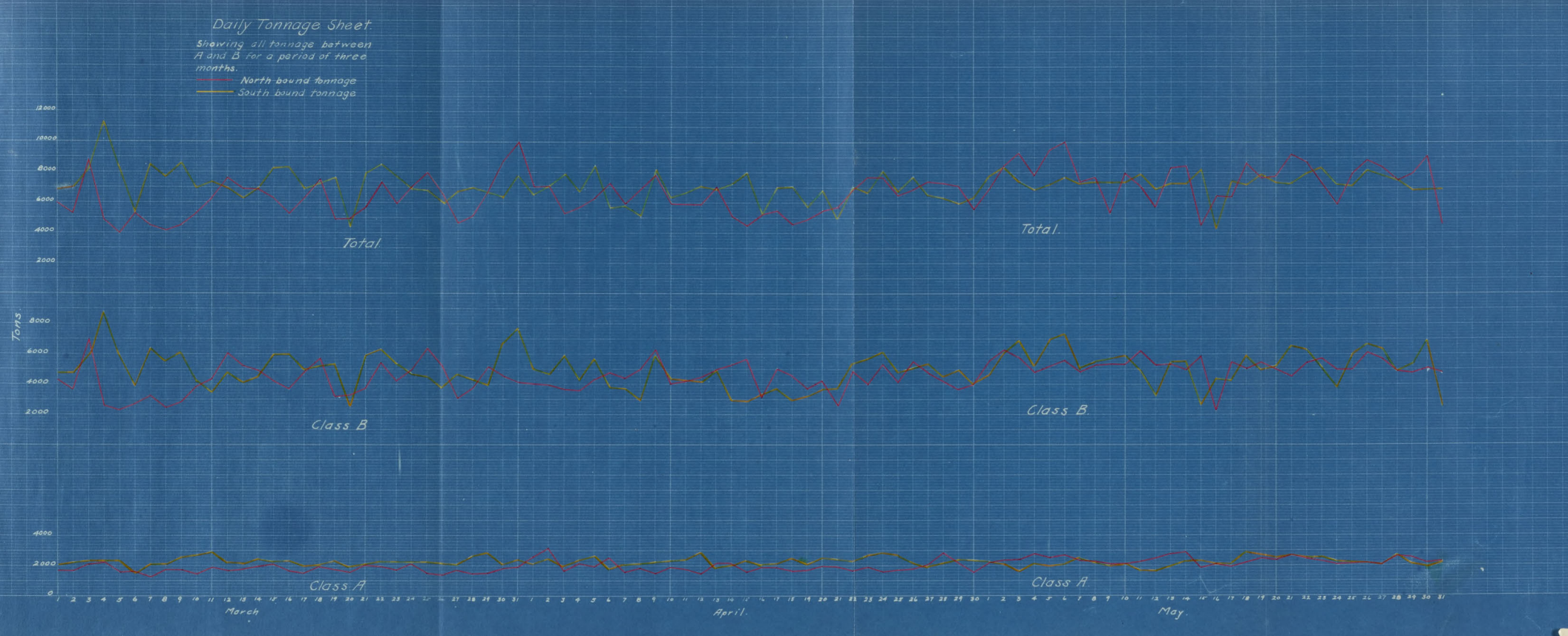
Slide Plates:		
1 set of Slide Plates	at $5.00	$ 5.00
Rail Braces:		
28 Rail Braces	at 8 3/4 ¢	2.45
Head Rod:		
1 Head Rod	at $2.00	2.00
Switch Stand:		
1 No. 1 Switch Stand Complete		13.00
Briddle Rod:		
1 Briddle Rod	at $1.00	1.00
Lamp, etc:		
1 Lamp	at $3.75	3.75
1 Lock and Chain		0.37
		$258.28
Labor of putting in		26.72
	Total	$285.00

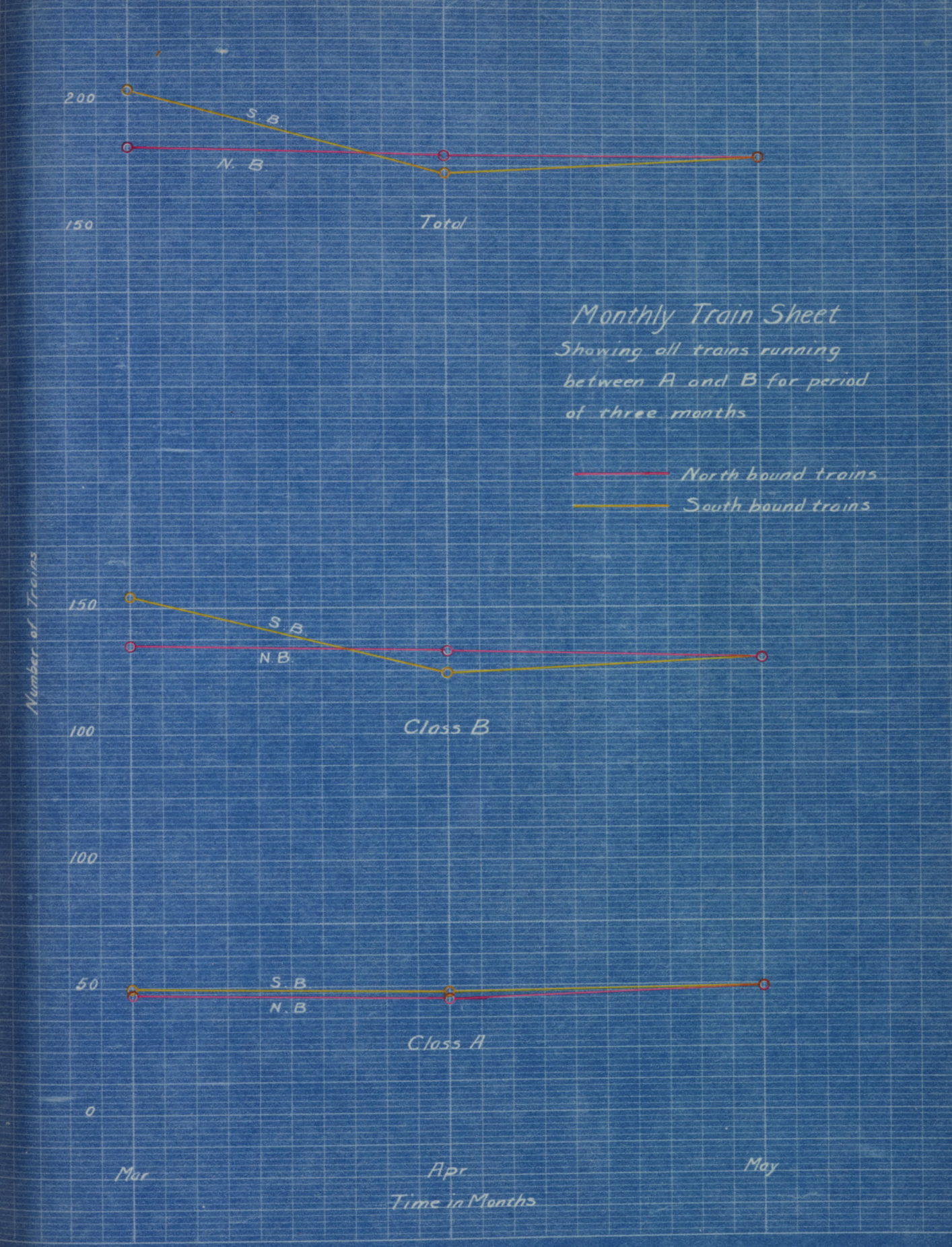

WORKING PROFILE
showing
PRESENT AND PROPOSED GRADES
between
A and B
Ferne
Reservoir
Ravine
Baskin
Banner
Haynes
Bridge
Dianna
Rene
Kirkham
Spencer
Western
Ravine
Denton
Wood
Bryant Pontile Paper
Bryant Pontile Paper

Daily Tonnage Sheet.

Showing all tonnage between A and B for a period of three months.

North bound tonnage
South bound tonnage




200
S. B.
N. B.
150
Total
Monthly Train Sheet
Showing all trains running between A and B for period of three months
North bound trains
South bound trains
Number of Trains
150
S. B.
N. B.
100
Class B
100
50
S. B.
N. B.
Class A
0
Mar
Apr
May
Time in Months